US006973235B2

(12) **United States Patent**
Zhou et al.

(10) **Patent No.: US 6,973,235 B2**
(45) **Date of Patent: Dec. 6, 2005**

(54) **OPTICAL FILTER DEVICE HAVING MOLDED, SINGLE-INDEX COLLIMATING LENS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 50 days.

(21) Appl. No.: **10/328,581**

(22) Filed: **Dec. 23, 2002**

(65) **Prior Publication Data**

US 2003/0138204 A1 Jul. 24, 2003

(30) **Foreign Application Priority Data**

Jan. 18, 2002 (TW) .... 91200442 U

(51) **Int. Cl.**[7] **G02B 6/32**
(52) **U.S. Cl.** **385/33**; 385/66; 385/72; 385/74
(58) **Field of Search** 385/33, 34, 66, 385/72–74, 139

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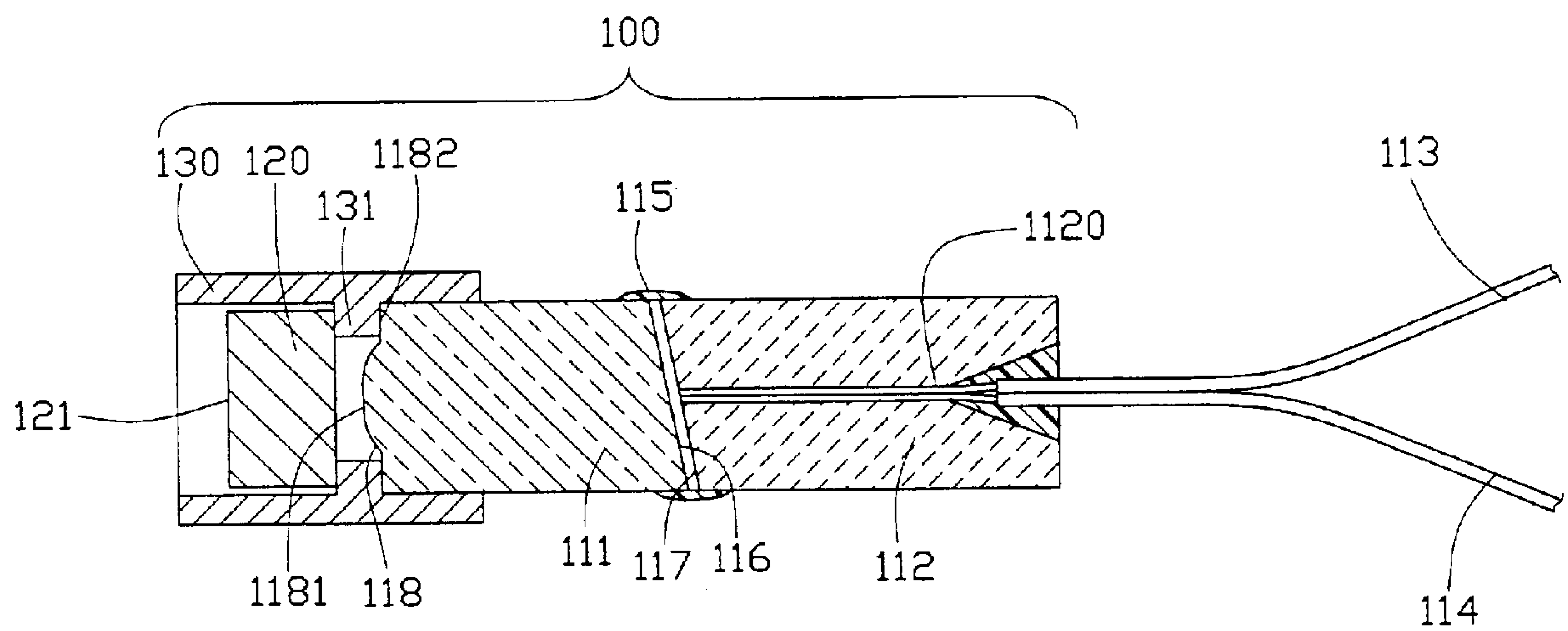
(57) **ABSTRACT**

An optical filter device **(100)** for collimating input signals and selecting optical signals in a predetermined wavelength band includes a dual fiber pigtail (DEP) **(112)** receiving an input and output optical fibers **(113, 114)**, a molded lens **(111)**, a sleeve **(130)**, and a filter **(120)**. The molded lens between the DFP and the filter has a single index. The molded lens collimates dispersed-light beams coming from the input optical fiber to parallel-light beams, and converges the parallel-light beams reflected by the filter for transmission into the output optical fiber. The filter absorbs optical light beams in predetermined wavelength bands. The sleeve allows connection of the filter to the lens without requiring use of epoxy on optically functional parts of the molded lens.

9 Claims, 3 Drawing Sheets



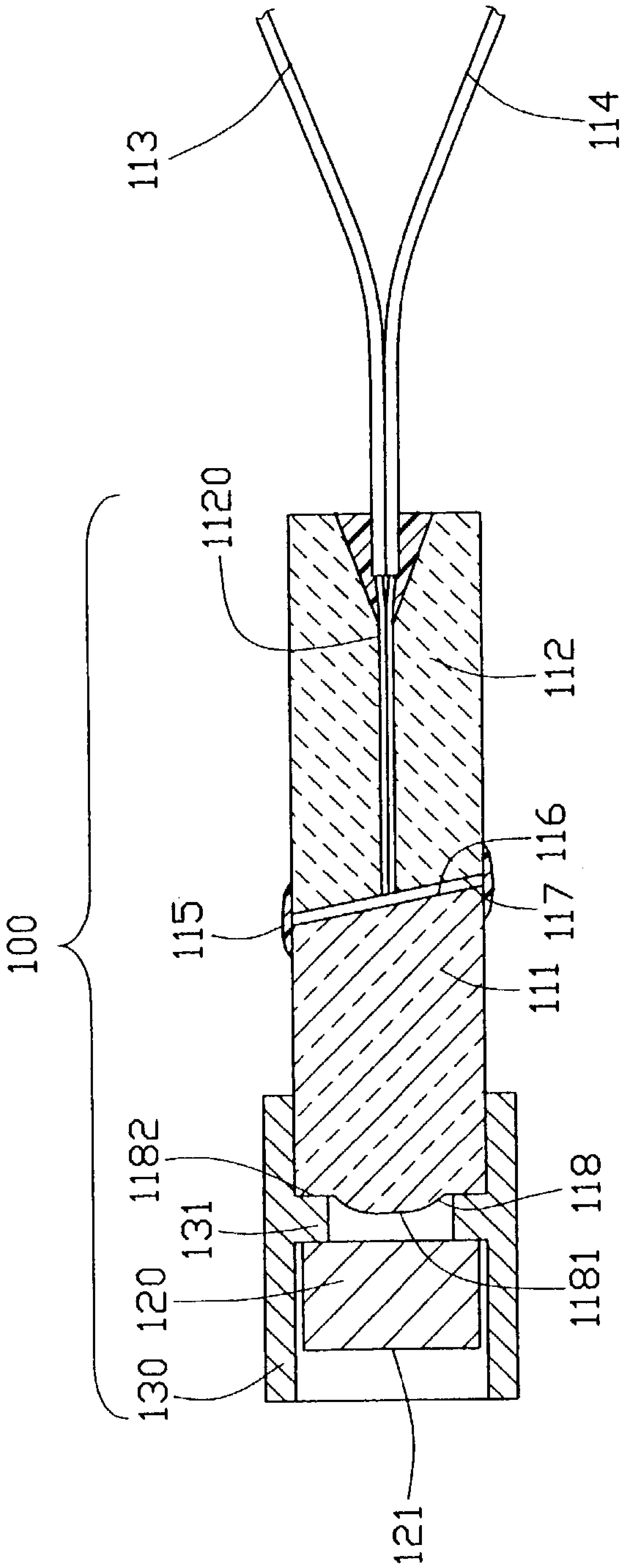
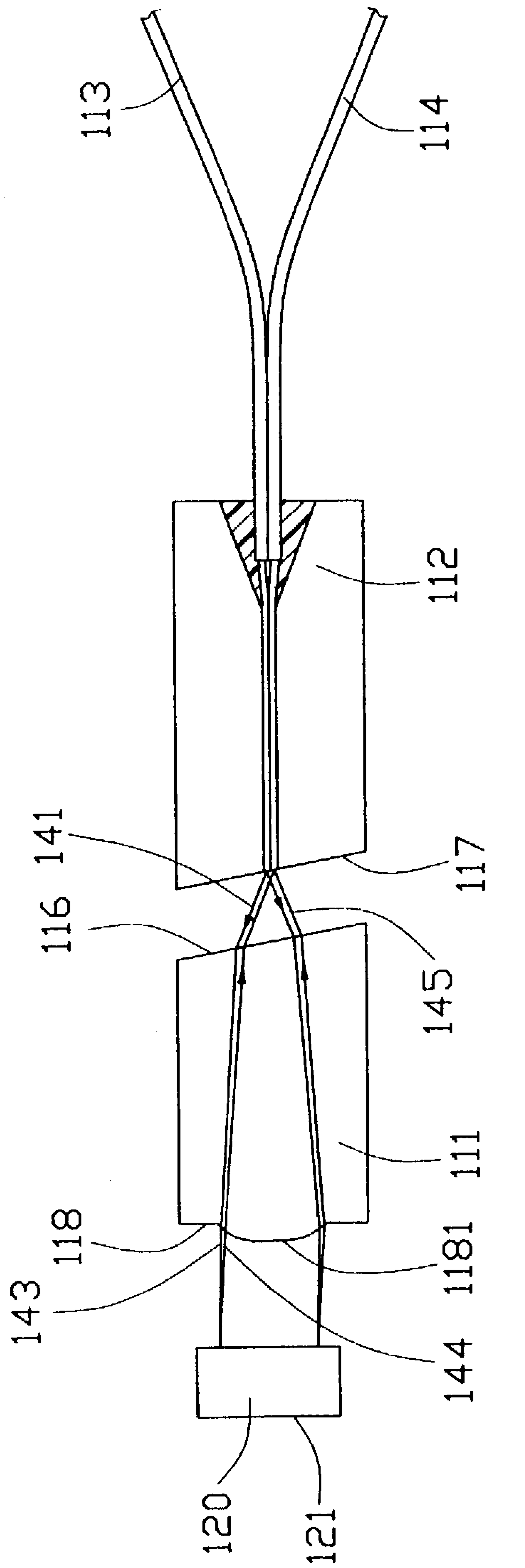

113
114
1120
112
100
115
116
117
111
1182
131
118
120
1181
130
121

FIG. 1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114
112
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116
145
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111
1181
143
144
120
121

FIG. 2

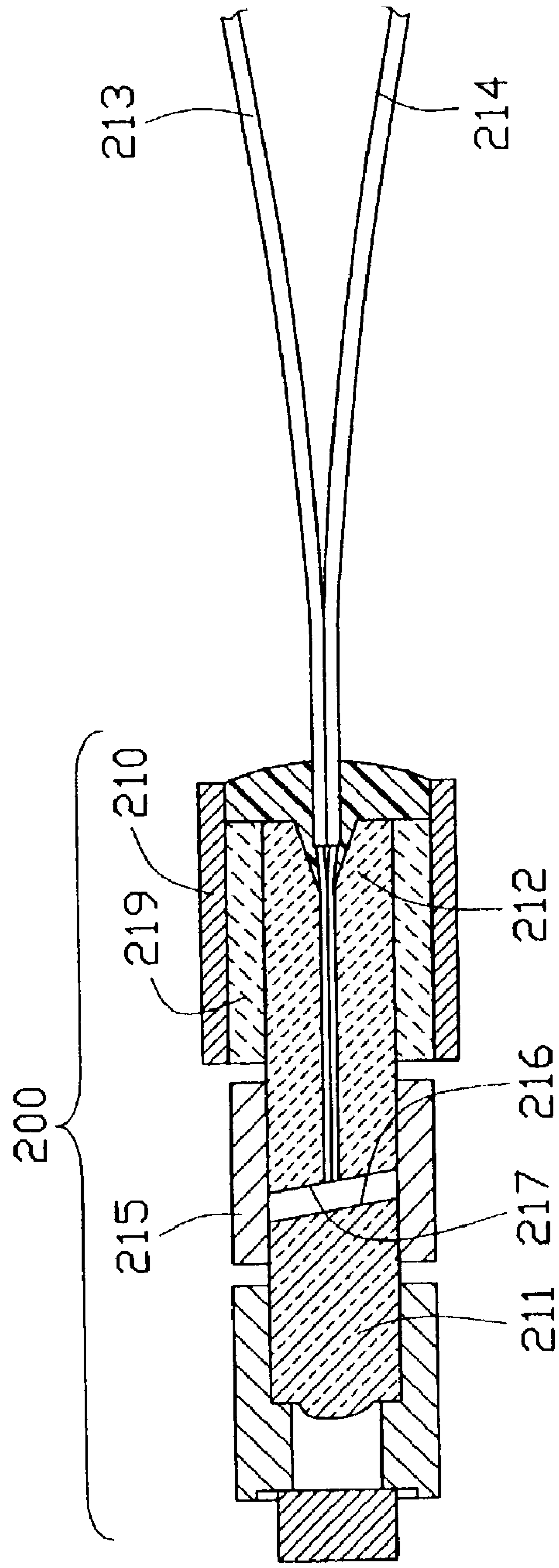
213
214
210
219
212
200
216
215
217
211

FIG. 3

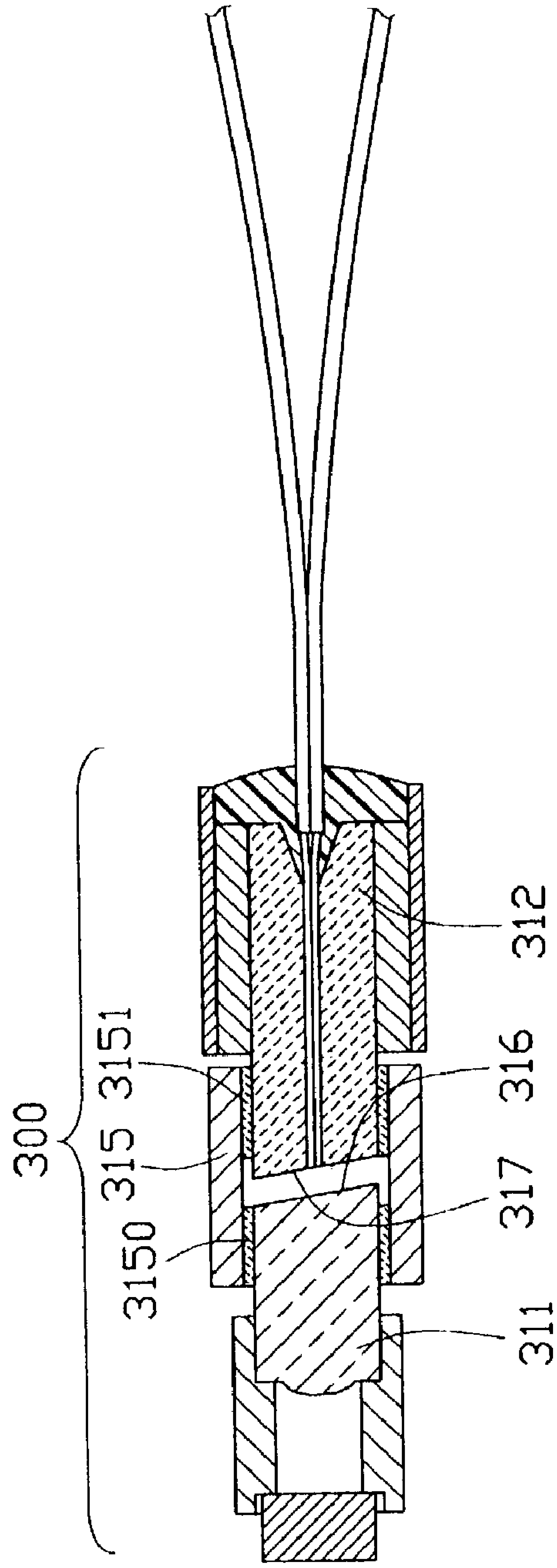
312
3151
316
300
315
317
3150
311

FIG. 4

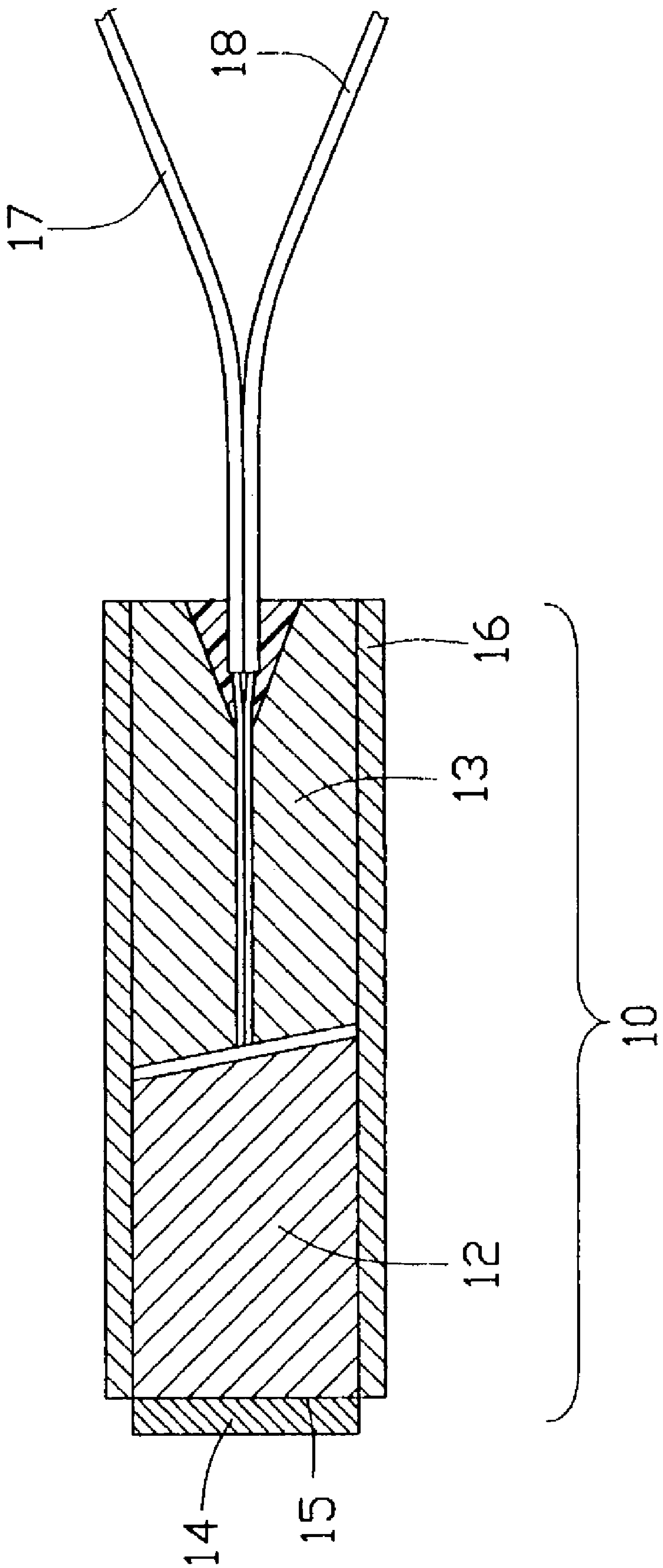

FIG. 5
(PRIOR ART)

OPTICAL FILTER DEVICE HAVING MOLDED, SINGLE-INDEX COLLIMATING LENS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to the field of optical filter devices, and more particularly to an optical filter device having a molded, single-index lens therein. This application relates to the applications Ser. Nos. 10/170,550 filed Jun. 11, 2002 and 10/163,822 filed Jun. 5, 2002, the latter application now U.S. Pat. No. 6,694,077, said applications having the same inventors and the same assignee as the present invention.

2. The Related Arts

The demand for higher transmission capacity and speed in optical communication systems is unrelenting. Dense Wavelength Division Multiplexing (DWDM) technology has been an important development to satisfy these demands, and is now widely used in optical communications systems.

A Graded Index (GRIN) lens is a popular optical collimating element, which is utilized in an optical filter device for collimating scattered light. As shown in FIG. **5**, a conventional filter **10** comprises an input optical fiber **17**, an output optical fiber **18**, a ferrule **13**, a GRIN lens **12**, a filter **14** and a sleeve **16**. The input and output optical fibers **17**, **18** are received in a through hole (not labeled) of the ferrule **13**. The ferrule **13** and the GRIN lens **12** are aligned and fixed in the sleeve **16** with epoxy resin. The filter **14** is attached to an end surface of the GRIN lens **12** with two epoxy resins. One type is UV epoxy, and the other type is NDT epoxy. UV epoxy has less fluidity and viscosity than NDT epoxy. In assembly, UV epoxy is first applied at an interface **15** between the GRIN lens **12** and the filter **14**. Then the NDT epoxy is applied around an outer surface of the filter **14**. A relatively large amount of NDT epoxy is required to cover the entire expanse of the interface **15**. The filter **10** is baked to permanently cure the NTD epoxy and the UV epoxy. The GRIN lens **12** and the filter **14** are thus fastened to each other.

The conventional filter device **10** has some disadvantages. First, the filter **14** is directly attached onto the surface of the GRIN lens **12** by epoxy resin. During baking of the two types of epoxy resin, the filter **14** is subjected to uneven heating. This changes and adversely affects performance of the filter **14**. Second, the GRIN lens **12** is conventionally made using the ion exchange method. This method requires that the GRIN lens **12** must be polished after initial formation, and this makes the GRIN lens **12** relatively expensive. Furthermore, chemicals used in the ion exchange method are harmful to workers and pollute the environment.

Therefore, an improved optical filter device that overcomes the above-described disadvantages of the conventional filter device is desired.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an optical filter device in which the collimating element is a molded lens.

Another object of the present invention is to provide an inexpensive optical filter device which yields good optical performance.

Yet another object of the present invention is to provide an optical filter device, the manufacture of which is more environmentally friendly.

To achieve the above-mentioned objects, a filter device for collimating optical signals in an optical system and selecting a predetermined wavelength band therefrom includes a fiber pigtail having at least one optical fiber, a molded lens collimating the optical signals coming from the at least one optical fiber, and a filter for selecting the optical signals in the predetermined wavelength band. The molded lens between the fiber pigtail and the filter has a single index. The molded lens collimates dispersed-light beams coming from the at least one optical fiber to parallel-light beams, and, conversely, focuses parallel-light beams not of the selected wavelength band which are reflected by the filter for transmission by the at least one or more optical fiber.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of an optical assembly in accordance with a preferred embodiment of the present invention;

FIG. **2** is an essential optical paths diagram of the optical assembly in FIG. **1**;

FIG. **3** is a cross-sectional view of an optical assembly in accordance with an alternative embodiment of the present invention;

FIG. **4** is a cross-sectional view of an optical assembly in accordance with another alternative embodiment of the present invention; and

FIG. **5** is a cross-sectional view of a conventional optical filter device.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, an optical filter device **100** in accordance with the present invention is used to collimate optical signals transmitted in an optical system and to select signals of predetermined wavelengths therefrom. The filter device **100** comprises a dual fiber pigtail (DFP) **112**, a molded lens **111** for collimating the optical light beams transmitted in the optical system, and a filter **120** for selecting the optical light beams in a predetermined band of wavelengths.

The DFP **112** is an elongated tube having a hollowed out interior aperture **1120** extending longitudinally therethrough. The interior aperture **1120** accommodates an input and output optical fibers **113**, **114**, which are fixed therein by use of epoxy resin (not labeled). The DFP **112** further has an angled front surface **117**, which is coplanar with two ends (not labeled) of the two optical fibers **113**, **114**. To improve the optical performance, the angled front surface **117** and the two coplanar fiber ends are polished at an oblique angle relative to an imaginary plane perpendicular to a longitudinal axis of the DFP **112**. The oblique angle is preferably between 6 and 8 degrees.

The molded lens **111** is made of glass or another suitable material with a single index. The molded lens **111** has an angled back surface **116** which is fixed parallel and opposite to the angled front surface **117**, and a front end face **118**. The front end face **118** comprises a curved face **1181** and a shoulder **1182**, the shoulder **1182** being formed around a periphery of the curved face **1181**.

The filter device **100** further comprises a cylindrical sleeve **130**. The cylindrical sleeve **130** has a through hole (not labeled) along a longitudinal axis, and an annular protrusion **131** projecting inwardly from an inner wall (not labeled) thereof. The protrusion **131** has a forward and a rearward side walls (not labeled).

The angled front surface **117** of the DFP **112**, and the angled back surface **116** and the front end face **118** of the molded lens **111** are all covered with anti-reflective coatings to minimize reflection of light signals traveling through the filter device **100**. In assembly, the filter **120** is attached to the forward sidewall of the protrusion **131** with epoxy resin, and the molded lens **111** is fixed on the rearward sidewall of the protrusion **131**, whereby the filter **120** is opposed to the curved face **1181** of the molded lens **111**. The DFP **112** and the molded lens **111** are held in fixed relation to one another, with the longitudinal axis of each being collinear. The angled front surface **117** and the angled back surface **116** are held parallel with epoxy resin **115**, with a distance between the angled front and back surfaces **117**, **116** being 0.025±0.015 mm.

FIG. **2** shows an essential optical pats diagram of the filter device **100**. Dispersed-light beams **141** from the input optical fiber **113** are collimated to parallel-light beams **143** by the molded lens **111**, and then transmitted to the filter **120**. The filter **120** is an absorption filter made of a material (e.g., germanium) that exhibits high absorption in a specific wavelength region. The filter **120** absorbs specific wavelength bands of the input parallel-light beams **143**, and further has a reflective surface **121** to reflect back remaining light beams **144** within a predetermined wavelength band. Traveling in a reverse direction through the molded lens **111**, the parallel-light beams **144** reflected by the filter **120** are focused to convergent-light beams **145** and are transmitted through the output optical fiber **114**.

FIG. **3** shows an alternative embodiment filter device **200** in accordance with the present invention. The filter device **200** makes use of a first tube **215** to receive one end of each of a molded lens **211** and a DFP **212** therein, for holding the molded lens **211** and the DFP **212** in fixed relation to one another. A distance between an angled front surface **217** of the DFP **212** and an angled back surface **216** of the molded lens **211** is larger than 0.04 mm. A second and a third tubes **219**, **210** accommodate the DFP **212** to protect the DFP **212**, wherein the second tube **219** receives another end (not labeled) of the DFP **212** and is contained in the third tube **210**. The third tube **210** is longer than the second tube **219**, so that epoxy resin can fill in a rearward portion of the third tube **210** to prevent the input and output optical fibers **213**, **214** from flexing excessively.

FIG. **4** shows another alternative embodiment filter device **300** in accordance with the present invention. The filter device **300** is similar to the filter device **200**, but has another two sleeves **3150**, **3151** with a same outside diameter. The sleeve **3150** receives one end (not labeled) of a molded lens **311** having an angled back surface **316**, and the sleeve **3151** receives one end (not labeled) of a DFP **312** having an angled front surface **317**. The molded lens **311** and the DFP **312** are held in fixed relation to each other by a first tube **315**, which contains the two sleeves **3150**, **3151**. An inside diameter of the first tube **315** is slightly larger than the outside diameter of the two sleeves **3150**, **3151**, for aligning the molded lens **311** with the DFP **312**.

The filter device **100** of the preferred embodiment of the present invention has the following advantages. No epoxy resin is required between the filter **120** and any optically functional part of the molded lens **111**. Accordingly, there are no problems with uneven heating. Additionally, the molded lens **111** can be formed as one integral, high-precision unit that does not require further polishing. This reduces costs. Furthermore, the material used to make the molded lens **111** is inexpensive, safe for workers and environmentally friendly. The above-described benefits are equally applicable to the filter devices **200**, **300** of the alternative embodiments of the present invention.

Further alternative embodiments of the present invention may include single fiber optical filter devices as well as the dual fiber optical filter devices described, and may further include other, similar optical devices, such as substituting the described filter with a Fabry-Perot Interferometer, a Bragg Grating, or a Fiber Bragg Grating.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What claimed is:

1. An optical filter device adapted to collimate optical signals coming from at least one optical fiber, and to select signals in a predetermined wavelength band from said optical signals to output, comprising:

at least one fiber pigtail for receiving and fixing the at least one optical fiber;

a molded lens fixed in series with the fiber pigtail for collimating the optical signals coming from the at least one optical fiber; and

a filter opposed to the molded lens and adapted to select signals of a predetermined wavelength;

wherein the molded lens is located between the fiber pigtail and the filter and has a single index, and collimates dispersed-light beams coming from the at least one optical fiber to parallel-light beams, and converges parallel-light beams of the predetermined wavelength which are reflected by the filter to pass into the at least one optical fiber.

2. The optical filter device of claim **1**, wherein the optical filter device further comprises a sleeve for fixing the filter and the molded lens together in relative engagement with each other.

3. The optical filter device of claim **1**, wherein the molded lens is connected with the fiber pigtail by epoxy resin or a tube.

4. The optical filter device of claim **1**, wherein the molded lens further has an angled back surface parallel and opposite to an angled front surface of the fiber pigtail.

5. The optical filter device of claim **4**, wherein the two angled front and back surfaces and a front end of the molded lens are covered with anti-reflective coatings.

6. The optical filter device of claim **4**, wherein a distance between the two angled front and back surfaces is larger than 0.04 mm.

7. The optical filter device of claim **1**, wherein the filter further comprises a reflective surface to reflect light signals.

8. An optical filter device comprising:

a fiber pigtail receiving at least one optical fiber therein;

a molded lens fixed to said fiber pigtail and having a curved face at a front portion thereof;

a filter oppositely and axially spatially positioned in front of said molded lens; and

a holding device including a cylindrical sleeve to retain the front portion of the lens and the filter therein.

9. The optical filter device of claim **8**, wherein said holding device further includes an interior annual protrusion against which said filter and said front portion of the lens axially abut, respectively.

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